GAS WARFARE

WITH SPECIAL REFERENCE TO THE DEFENSE OF THE MIDDLE WEST

by
James K. Senior

The object of the course which begins today is to give the physicians of the Middle West such information as may enable them efficiently to handle cases of gas intoxication, should this region ever be subjected to a war gas attack. As to the likelihood of such an event, opinions differ. One reason for this disagreement is that methods of warfare are now changing so rapidly that it is very difficult to predict what the near future may bring forth. It is, however, certain that unpreparedness is the surest means of inviting attack. For these reasons, those in command of the armed forces of the United States have wisely decided that this country must be thoroughly prepared both offensively and defensively for every form of gas warfare. The present course is an item in the defense program designed to carry this decision into effect.

The plan of the course has already been given to you. Most of the lectures and demonstrations will be devoted to specifically medical subjects--the pathology, first aid and therapy of war gas casualties. These medical exercises are preceded by a talk dealing with more general aspects of gas warfare--the tactics involved, the chemistry of the common war gases, and the non-medical aspects of anti-gas defense--all treated with special reference to the defense of the Middle West. Such an introductory lecture is included in the course because an intelligent man usually performs his own duties better and cooperates with his fellow workers more effectively if he knows "what it is all about" than if he blindly carries out instructions.

Military necessity forces me to begin this introductory lecture with a word of caution. All that I can say on the present occasion must be confined to what might be called the classical aspects of gas warfare. Most of the information about new war gases or new methods either of attack or of defense is a closely guarded military secret. All the material which I shall present is, therefore, merely a short excerpt from what has already been made public. Those who desire more extensive knowledge of the subject will find any one of the following books a satisfactory source of information. (SlideA) Should toxic agents or tactical methods never previously discussed in public be used in an attack on this region, the doctors of the Middle West will have to rely on instructions which may be expected to be issued at that time by the Army Medical Corps. In default of such instructions, they will have to depend on their own good sense and skill as physicians.

Before discussing what gas (in the military sense of that term) is, a word or two is in order as to what it is not. Gas, as that word is used by the armed forces, has nothing whatever to do with the substance burned in a kitchen range. Neither has it any connection with what goes into the tank or what comes out of the exhaust of an automobile. Military gas masks give very little protection against most of the asphyxiating agents commonly met with in civil life, and most of the experience acquired in the treatment of peace-time cases of asphyxia is useless in the treatment of war-gas casualties. Indeed, many of the effective peace-time methods are strongly contra-indicated in the handling of war gassed cases.

Another peculiarity of the war gases is that many of them are not gases at all, in the physicist's sense of that term. A number of them, under ordinary atmospheric conditions, are more or less volatile liquids; some are even solids. In view of this fact, it is rather difficult to give a definition of just what "gases" in the military sense really are. They may be described as non-living agents (usually air-borne) which affect the human organism by intoxication rather than by impact. This definition excludes bacteria on the one hand and missile, explosive or cutting weapons, on the other.

To assist in following the ensuing discussion, I give (Slide 1) a list of eight gases extensively used during the First World War. They are classified according to the two properties which, in my opinion, are most important for the purposes of the present lecture--their relative persistence and their mode of attack on the human body. Later on, I shall return to a more detailed discussion of these agents taken individually.

It follows almost directly from the definition given a moment ago that the war gases, as means of destroying property, are practically valueless. Gas is essentially a weapon to be used against personnel. When so employed, its use is governed by two characteristics common to all the war gases:

(1) Their peculiar distribution in both time and space.
(2) Their complementary action with respect to missile and explosive weapons.

How these characteristics control the use of gas, I shall attempt to explain.

Missile weapons pepper the target at which they are aimed. Of three soldiers in line under machine gun fire, the first and third may be hit, while the middle man may escape unscathed. Gas never acts that way. It sweeps over its target affecting everyone within the area covered. Explosives have a mixed action. Insofar as their effect is due to the scattering of solid fragments, they resemble missile weapons; insofar as their effect is due to blast, they resemble gas. But around an explosion, the area made dangerous by blast is small. For blanketing larger areas, gas is by far the most effective means.

With respect to distribution in time, gas is almost a unique war agent. The soldier in the line of flight of a bullet or a shell fragment is injured if he is caught on that line precisely at the right moment. But if he crosses that line a fraction of a second before or after the passage of the missile, he is unharmed. Within a second after an explosion, almost all of its effect is over. On the other hand, a characteristic feature of gas is the relative persistence of its toxic action. A single shell filled with phosgene (one of the most evanescent of the war gases) creates a small gas cloud which, even under unfavorable circumstances, produces injuries for at least fifteen seconds. The more persistent gases such as mustard may, in protected locations, continue to cause casualties for weeks or even months.

All of the effect of the non-persistent gases and a large part of the effect of the persistent ones is exercised when they are borne by the air against their target--that is the bodies of the persons attacked. For this reason, these agents must theoretically be somewhat heavier than air, and in practice it is found necessary to use only substances which are very much heavier.

Another peculiarity of the war gases is that many of them are not gases, really, in the physicist's sense of that term. A number of them, under ordinary atmospheric conditions, are more or less volatile liquids; some are even solids. In view of this fact, it is rather difficult to give a definition of just what "gases" in the military sense really are. They may be described as non-living agents (usually chemicals) which affect the human organism by intoxication rather than by impact. This definition excludes bacteria on the one hand and missile, explosive or cutting weapons, on the other.

To assist in following the ensuing discussion, I give (Slide 1) a list of eight gases extensively used during the First World War. They are classified according to the two properties which, in my opinion, are most important for the purpose of the present lecture--their relative persistence and their mode of attack on the human body. Later on, I shall return to a more detailed discussion of these agents taken individually.

It follows almost directly from the definition given a moment ago that the war gases, as means of destroying property, are practically valueless. Gas is essentially a weapon to be used against personnel. When so employed, its use is governed by two characteristics common to all the war gases:

(1) Their peculiar distribution in both time and space.
(2) Their complementary action with respect to missile and explosive weapons.

How these characteristics control the use of gas, I shall attempt to explain.

Missile weapons affect only the target at which they are aimed. Of three soldiers in line under machine gun fire, the first and third may be hit, while the middle one may escape unscathed. Gas never acts that way. It sweeps over the target affecting everyone within the area covered. Explosives have a mixed action. Insofar as their effect is due to the scattering of solid fragments, they resemble missile weapons; insofar as their effect is due to blast, they resemble gas. But in any explosion, the area made dangerous by blast is small. For blanketing larger areas, gas is by far the most effective weapon.

With respect to distribution in time, gas is almost a unique war agent. The soldier in the line of flight of a bullet or a shell fragment is injured if he is caught on that line precisely at the right moment. But if he crosses that line a fraction of a second before or after the passage of the missile, he is unharmed. Within a second after an explosion, almost all of its effect is over. On the other hand, a characteristic feature of gas is the relative persistence of its toxic action. A single shell filled with phosgene (one of the most nonpersistent of the war gases) creates a small gas cloud which, even under unfavorable circumstances, presents infection for at least fifteen seconds. The more persistent gases such as mustard may, in protected locations, continue to claim casualties for weeks or even months.

All of the effect of the nonpersistent gases and a large part of the effect of the persistent ones is exerted when they are borne by the air against their target--that is the bodies of the persons attacked. For this reason, these agents must theoretically be somewhat heavier than air, and in practice it is found necessary to use only substances which are very much heavier.

Otherwise, they are rapidly dissipated upwards into the atmosphere and become too dilute for effective use against ground targets. The tendency of heavy vapors or mists is to flow along the ground, following the contour lines to low-lying spots. Particularly, they tend to collect in excavations such as foxholes, dugouts or cellars--the very locations which offer the best protection to personnel against attack with missile or explosive weapons. In the field, a soldier runs the least chance of being injured by gas if he occupies a position on a smooth, sunlit, wind-swept hillside bare of trees, bushes or high grass--that is, a position in which he is almost perfect target for rifle, machine-gun or artillery fire. Carefully gas-proofed dugouts offer a means of escape from this dilemma, but their construction is laborious and time-consuming. Such elaborate shelters are out of the question for any troops, except these occupying fixed positions. In gas attacks on urban civilian populations, the situation is complicated by certain peculiar features of the tactics which would probably be used on such occasions.

The general subject of gas tactics can only be touched upon in the present lecture. In the military text-books, it is customary to divide the terrain held by the enemy into successive zones, beginning at the line of contact between the two armies and extending back over the whole of the enemy territory. There have been developed methods for delivering gas attacks in each one of these zones. But attention will here be confined to the rearmost area--the largest one of all--which includes the bulk of the enemy territory far from the front line. This restriction is based on the assumption that, if the Middle West is ever subjected to a gas attack, that attack will very probably be delivered by a far distant enemy, ~~and~~ not by one intrenched within five miles of his objective. Under these conditions, this region will be located in the rear zone, and (disregarding sabotage) the only feasible method of introducing gas into the the rear zone is by distributing it from airplanes. Consequently, I shall not discuss the distribution of gas by projectors, artillery shell and other weapons designed for use in the forward zones. Another limitation on my discussion will be that I shall confine attention to the possible gassing of urban areas. For reasons which will be obvious as I go on, the chance that the enemy will ever attempt to gas the farm lands of Iowa is too remote to deserve consideration.

No gas attack by airplane was ever carried out during the last war. However, there are two well authenticated uses of gas in the present world conflict. The Italians released mustard from airplanes in the path of advancing Ethiopians, and the Japanese may have used airplanes at Ichang, October 7-8, 1941, when they distributed a mixture of 75% mustard gas and 25% Lewisite in a defensive action against the Chinese. I have no detailed information about the effectiveness of these attacks. The general subject of gas attack from the air has, however, received some attention from military theorists, and something may be said about the various possibilities. Two methods for conducting such attacks present themselves. The first (which I shall call the "bomb method" is to load the gas into containers which are to be dropped from the plane. These containers either explode on impact, as do high explosive bombs, or else are so lightly constructed that they shatter when they strike the target. In either case, the gas contents are liberated and scattered right on the target when the container is opened. The second method (which I shall call the spray method) is to load the liquid toxic agent into a large tank carried by the plane. By a suitable mechanism, this liquid is delivered from the tank in the form of a spray. The idea is to release such a spray at a considerable height,

Otherwise they are useful [illegible] into the shellholes and trenches [illegible] effective only against ground targets. The tendency of heavy vapors to flow along the ground, following the contour lines to low-lying spots. Particularly, they tend to collect in excavations such as fox-holes, dugouts or cellars--the very locations which offer the best protection to personnel against attack with missile or explosive weapons. In the field, a soldier runs the least chance of being injured by gas if he occupies a position on a mountain summit, wind-swept hillside bare of trees, bushes or high grass--that is, a position in which he is almost perfect target for rifle, machine-gun or artillery fire. Carefully gas-proofed dugouts offer a means of escape from this dilemma, but their construction is laborious and time-consuming. Such elaborate shelters are out of the question for any troops, except those occupying fixed positions. In gas attacks on urban civilian populations, the situation is complicated by certain peculiar features of the tactics which would probably be used on such occasions.

The general subject of gas warfare can only be touched upon in the present lecture. In the military text-books, it is customary to divide the terrain held by the enemy into successive zones, beginning at the line of contact between the two armies and extending back over the whole of the enemy territory. There have been developed methods for delivering gas attacks in each one of these zones. But attention will here be confined to the farthest area--the farthest behind the lines--because the bulk of the enemy territory is far from the front lines. This restriction is based on the assumption that, if the Middle West is ever subjected to a gas attack, that attack will very probably be delivered by a far distant enemy and not by one intrenched within five miles of his objective. Under these conditions, this region will be located in the rear zone, and (barring raids by parachutists) the only feasible method of introducing gas into the rear zone is by distributing it from airplanes. Consequently, I shall not discuss the distribution of gas by projectiles, artillery shell and other weapons designed for use in the forward zones. Another limitation on my discussion will be that I shall confine attention to the possible gassing of urban areas. For reasons which will be discussed later, I think it unlikely that the enemy will ever attempt to gas the inhabitants of farms in the effort to [illegible] completely.

No gas attack by airplane was ever carried out during the first world war. However, there are two well authenticated uses of gas in the present world conflict. The Italians released mustard from airplanes in the path of advancing Ethiopians, and the Japanese may have used airplanes at Ichang, October 7-8, 1941, when they distributed a mixture of 75% mustard gas and 25% lewisite in a defensive action against the Chinese. I have no detailed information about the effectiveness of these attacks. The general subject of gas attack from the air has, however, received some attention from military theorists, and something may be said about the various possibilities. Two methods for conducting such attacks present themselves. The first (which I shall call the "bomb method") is to load the gas into containers which are to be dropped from the plane. These containers either explode on impact, as do high explosive bombs, or else are so lightly constructed that they shatter when they strike the target. In either case, the gas contents are liberated and scattered right on the target when the container is opened. The second method (which I shall call the spray method) is to load the liquid toxic agent into a large tank carried by the plane. By a suitable mechanism, this liquid is delivered from the tank in the form of a spray. The plane is to release such a spray at a considerable height,

and allow it to be carried by the force of gravity onto the target. It should be noted that in neither of these methods is the gas ever placed in a container which has to withstand the shock of a propellant charge--as an artillery shell does. Hence, the container may be of very light construction. This is an important military consideration, for it means that, in order to get a given amount of gas onto the target, there is no need to accompany the toxic charge with a large amount of almost useless metal. For this reason, a gas attack delivered by airplane and employing either the bomb or the spray method has certain attractive military features.

Turning first to the bomb method, it may be stated that the dropping of gas-filled bombs from planes does not seem to offer any peculiar difficulties. This scheme could probably be carried out by the devices ordinarily used to drop high explosive or incendiary bombs. If (as is probable) the bombs used were light-walled ones, intended to shatter on impact, their value as missiles would be slight, and few casualties would result from scattered fragments of their casings. The noise of impact of such bombs would be small as compared to the noise caused by the bursting of high-explosive bombs. In the excitement of an attack from the air, this noise might even escape notice. Except in very closely built-over areas, most of the bombs would fall on the ground. The discharge of their gas contents would build up a low-lying gas cloud which would tend to flow into cellars, sewers, etc. Low-lying shelters, in order to serve as safe refuges during such an attack, would have to be thoroughly gas-proofed. Gas-proofing, in the permanent buildings of an urban area, would, however, offer much less difficulty than corresponding measures in dugouts on the field. Moreover, the upper stories of buildings, perhaps even the second stories of dwelling houses, would probably project above the gas cloud, and would thus offer fairly safe refuge, once the actual dropping of bombs had ceased. Roofs, unless they had actually been struck by bombs containing persistent gases, would be equally safe.

With regard to the spray method, the first point to be noted is that this mode of attack is applicable only where persistent gases are used. Of a non-persistent gas released in the air high above the target, very little would ever reach the ground. The second point is the distinct possibility of carrying out a spray attack in such a way as to produce an important surprise effect. The fall of a spray is noiseless. If the distributing plane were also noiseless (possibly a glider), and the toxic agent used had little or no odor, the gas might well be on the target before it was known that an attack had been made. There might be no alert signal or warning of any sort. Such an attack would undoubtedly produce many casualties.

Since, in a spray attack, only relatively non-volatile liquids can be used, all surfaces (and particularly horizontal ones like streets or flat roofs) exposed during such an attack would be pretty well contaminated with fine liquid droplets. The area covered (in contrast to that covered in a bomb attack) would probably be fairly continuous. Hence, escape by retreat into an ungassed area would be difficult. Obviously, contaminated roofs or streets would be places to avoid. But the persistent gases, which alone are suitable for spray attacks never build up very concentrated gas clouds. Hence, a room on the second, but preferably on a higher floor of a building would be a fairly safe place of refuge, provided that room (and to a lesser extent the whole building) were well sealed against the outside air.

out or cannot be dropped by the force of gravity onto the target. It should be noted that in neither of these methods is the gas ever placed in a container which must withstand the shock of a projectile or the pressure of an explosive shell charge. The containers from which the gas is released may be of very light construction. This is an important military consideration, for it means that, in order to get a given amount of gas onto the target, there is no need to accompany the toxic charge with tons of heavy and largely useless metal. For this reason, a gas attack employing either the bomb or the spray method has a much greater military efficiency [illegible].

With reference to the bomb method, it may be stated that the dropping of heavy bombs from planes does not seem to offer any peculiar difficulties. This method would probably be carried out by the devices ordinarily used to drop high explosive or incendiary bombs. If (as is probable) the bombs used were large, thin-walled bombs, intended to shatter on impact, their value as missiles would be small, and the casualties would result from scattered fragments of them and not from the blast. The noise of impact of such bombs would be small as compared to the thunder of the explosion of high-explosive bombs. In the excitement of an attack from the air, this noise might even escape notice. Except in very closely built-up urban areas, most of the bombs would fall on the ground. The liquid contents, as the gas came out, would build up a low-lying gas cloud which would seep through cellars, sewers, etc. Low-lying shelters, in order to serve as safe refuges during such an attack, would have to be thoroughly gas-proofed. Sheltering in the permanent buildings of an urban area, would, however, serve [illegible] measures in [illegible]. The upper storeys of buildings, perhaps even the second stories of the buildings, would be relatively [illegible] surprise attack. [illegible] the distribution of the gas [illegible] the toxic gas [illegible] little or no [illegible].

With regard to the spray method, the first point to be noted is that this method is applicable only where persistent gases are used. Of a non-persistent gas released in the air high above the target, very little would ever reach the ground. [illegible] exposed [illegible] would be pretty well saturated with fine liquid droplets. The area covered (in contrast to that covered in a bomb attack) would probably be fairly continuous. Hence, escape by retreat into an unaffected area would be difficult. Obviously, contaminated roofs or streets would be places to avoid. But the persistent gases, which alone are suitable for spray attacks never build up very concentrated gas clouds. Hence, a room on the second, but preferably on a higher floor of a building would be a fairly safe place of refuge, provided that room (and to a lesser extent the whole building) were well sealed against the outside air.

In all that I have said about refuge from gas either during or after attack, I have considered only the man inside a building who is attempting to protect himself from gas on the outside. But what happens when the gas is released within the building? Clearly this can never occur when the spray method is used. A gas bomb, it is true, might penetrate a building and burst inside. But since the penetrating power of such bombs would probably be low, I would expect interior bursts to be rare. If such an incident should occur, the building, or at least that part of it where the burst occurred, would have to be immediately evacuated. Where the occupants went would not make much difference, since almost any other place would be safer than the one they came from.

Discussion of the particular agents to be expected in either bomb or spray attacks is postponed until the common war gases have been reviewed in detail.

Thousands of agents toxic to the human organism are known, and hundreds have been tested in the laboratory for their efficacy as war gases. But the conditions which a successful war gas must meet are so stringent that, in the last war, not more than a dozen compounds proved of any importance in the field, and of these, two, namely mustard gas and phosgene, accounted for the great majority of the gas casualties in the American Army.

The first of the necessary conditions is that the agent must have a very high toxicity--that is, it must be effective at very low concentrations. Out of doors, it is difficult to build up in the atmosphere over any considerable area a toxic gas concentration as high as one-tenth of a per cent. Air currents and diffusion tend rapidly to dilute the gas. Most of the effective toxic agents are more or less quickly hydrolyzed by water and thereby converted into relatively harmless substances. Rain rapidly washes them out of the atmosphere and destroys them. All of the agents found to be effective in the field are highly toxic at concentrations less than one milligram in ten liters. The difficulties just mentioned with respect to concentration do not apply when gas is introduced directly (for instance by shell burst) into a dugout or an occupied room in a building; but the probability of planting a gas shell or gas bomb with such accuracy is low. With gas, as with other military weapons, calculations of efficiency must be based on probable average performance, not on the spectacular results which may be obtained by an occasional freak shot.

The second important desideratum for a successful war gas is availability. Gas is valueless unless used in considerable quantities. To sprinkle a landscape with little patches of toxic material is a waste of effort and money. It is essential to create a continuous gas cloud over a considerable area. Consequently, of the many chemical compounds which, if judged solely by their physical and physiological properties, would be admirable toxic agents, the great majority are out of the question as war gases, either because the raw materials for their manufacture are too scarce, or because the methods for preparing them are too difficult to permit them to be manufactured in effective quantities.

A third important consideration for a war gas is its stability. Many highly toxic substances are so unstable that they do not stand the rather strenuous conditions of storage and transportation between the point of manufacture and the point of discharge, or the effect of the explosion which releases them. It should never be forgotten that the important thing about any sort of gas container is not what goes into it but what comes out of it.

As stated above, I am [illegible] attack. [illegible] But what happens when the [illegible] is released? [illegible] penetrate a building and burst inside. [illegible] of such bombs would probably be low, I would expect [illegible]. If [illegible] should occur, the [illegible] that part of it where the burst occurred, would have [illegible]. Where the occupants [illegible], since almost any other place would be safer than the one they came from.

Dissemination [illegible]

Dissemination of the particular agents to be employed in either bomb or spray [illegible] until the [illegible] have been [illegible].

The size of [illegible] in the human organism are known, and [illegible]. But the [illegible] so stringent that, in the [illegible] adequate proof of any important [illegible] calculated [illegible] in the [illegible] area.

The first of [illegible] considerations is that the agent must have a very high [illegible], that is, it must be effective at very low concentrations. [illegible] in the atmosphere over any considerable area [illegible] of 1 per cent. Air currents and [illegible] of the effective agents [illegible] destroys them. All of the agents thought to be effective in [illegible] are highly [illegible]. The difficulties [illegible] than a [illegible] both with [illegible] weapons, [illegible] with other military weapons, [illegible] performance, [illegible] results which may be obtained by [illegible] shot.

The second [illegible] for a [illegible] war [illegible] is availability. [illegible] possible. To [illegible] is a waste of effort and energy. It is necessary to [illegible] over [illegible] areas. [illegible] and physiological properties [illegible] majority [illegible] for their [illegible], or because the methods for [illegible] are too difficult [illegible] in effective quantities.

A third important consideration [illegible] is stability. Many [illegible] toxic substances [illegible] the rather [illegible] conditions of storage and [illegible] of the [illegible] and [illegible] explosion which releases them. It should never be forgotten that the [illegible] which any sort of [illegible] container is [illegible] what [illegible] comes out of it.

A fourth item to be considered in connection with any toxic agent is the relative difficulty of establishing protection against it. In the field, the chief instrument of protection for the individual soldier is the gas mask. But the efficacy of all military masks depends greatly on the toxic substance used. Obviously, the more readily a gas penetrates the masks of the enemy, the greater is its value as a war agent. Continuing the same line of reasoning, it is also evident that a gas which acts directly on the skin is much more difficult to protect against than one which attacks only through the respiratory tract or the eyes. In the last war, skin vesicants were among the most successful of all the toxic agents used. I shall have more to say about skin protection later on.

The four essential or desirable properties for a war gas which have been given by no means exhaust the list of such requirements. Those mentioned are the ones which seem to me most important. But what I have said should be enough to convince you that, although toxic compounds are common enough, really effective war gases are extremely rare.

All gases which have actually been used in the field resemble one another in one important respect. Their action, at least within practical limits, is directly proportional to the amount of gas which reaches its point of attack on the human body. This amount is in turn proportional to the product of the concentration of the gas and the time of exposure. That is to say, for any particular gas, exposure for one minute to a concentration of one milligram per liter does about as much harm as exposure for ten minutes to a concentration of one tenth of a milligram per liter. This rule, however, applies only to true gases, in the physical sense of that term. It is inapplicable to vesicant liquids sprinkled over the skin or clothing of the victim. And even for true gases, the rule quoted holds only within limits. The limitation in the region of high concentration is of little consequence because such dense gas clouds are scarcely ever met with under field conditions. But it is important to remember that, for every toxic gas, there is a minimum concentration for effective use. If the concentration of the agent in the air falls below that limit, a man may live indefinitely in an atmosphere thus contaminated either without experiencing any effect or, at most, without suffering more than trivial annoyance. Many compounds which, in the laboratory, are extremely toxic are useless as war gases because, in the field, it is impossible to produce effective atmospheric concentrations of these substances. In this connection, weather conditions play an important role. For example, at temperatures below freezing, mustard gas is so slightly volatile that it loses much of its immediate effectiveness. In very hot weather, phosgene is so rapidly dissipated that huge amounts of it are required in order to keep up effective atmospheric concentrations for more than a few seconds.

Turning again to the table (Slide 1) of gases, I may say that the classification according to toxic properties is, to some extent, arbitrary. All of the compounds listed are nasty substances to handle. A good many of them act on the human organism in more ways than one. Mustard gas, for example, although primarily a vesicant, will, if inhaled long enough, produce severe lung injuries. Chlorpicrin, in addition to being a lung injuriant, is also a mean lacrimator. All of the arsenicals on the list, by virtue of their arsenic content, can and do occasionally act as general systemic poisons.

The statements about persistence should also not be taken too precisely. Wind, rain, and temperature modify the length of time during which a toxic agent persists in any given location. The figures which I shall give you all refer to measurements made out of doors. In an enclosed space like a cellar, almost any war gas will last long enough to be called persistent.

The descriptions of odors which appear on the coming slides are taken from the published tables. But, in my opinion, whoever is responsible for these tables must be gifted with a vivid imagination. I have smelled plenty of phosgene, but none of it ever reminded me of either musty hay or green corn. In any case, too much reliance is not to be placed on these olfactory tests. Even if one is very familiar with the odor of a particular war gas, when the vapor of that substance is wafted to his nostrils by a breeze laden with attar of cess-pool or essence of burnt horse, he may not recognize his old friend.

Let us turn to the individual gases.

Mustard gas (Slide 2) was one of the most effective gases and by far the most effective vesicant used in the last war. It was responsible for about seventy-five per cent of the gas casualties suffered by the American Army. The reason for this high effectiveness doubtless lies in the insidious nature of the substance. Its odor is so mild that, in the excitement of battle, it may easily pass unnoticed. Its effect on the organism is delayed. Frequently, the first annoying symptoms appear only after a lapse of several hours. Consequently, many soldiers were unaware of the presence of mustard gas at the moment of their contamination. By the time they knew that they had been gassed, they were already prospective hospital cases. Exposure for ten minutes to a concentration of one milligram of mustard gas in six and a half liters of air is fatal. This substance, near the lower limit of its irritant concentration (one milligram in a thousand liters of air) may cause eye casualties in about an hour. Mustard gas has an extremely interesting history which lack of time unfortunately forbids me to recount. It was first identified in 1886 by Victor Meyer, was first used by the Germans in their famous attack at Ypres in July, 1917, and was later also used by the Allies.

Lewisite (Slide 3) is a home product. It was discovered by Dr. Lee Lewis, long a well-known chemist in Chicago. But it did not get into production in time to be used on the field during the last war. Like mustard gas, it is primarily a vesicant. Ten minutes exposure to a concentration of one milligram in eight and a half liters is lethal. One milligram in twelve hundred and fifty liters is about the lower limit of irritant concentration. Lewisite melts at a temperature lower than the melting point of mustard gas, and is therefore the better of the two for winter use. It is less persistent than mustard gas--a fact which, depending on the purpose for which the gas is used, may or may not be a military advantage. Lewisite hydrolyzes more rapidly than mustard. Its hydrolysis product, however, is still quite toxic, whereas that of mustard gas is not.

Ethyldichloroarsine (Slide 4) is both a vesicant and a lung injuriant. Ten minutes exposure to a concentration of one milligram in two liters is fatal. At low concentrations (one milligram in one hundred liters), this gas acts as a respiratory irritant, producing sneezing. The lower limit of irritation is one milligram in a thousand liters. Ethyldichloroarsine was used by the Germans in the last war, but never, so far as I know, by the Allies.

Chlorpicrin (Slide 5) is primarily a lung injuriant and secondarily a lacrimator. It is the least toxic of all the lethal gases. Ten minutes exposure to a concentration of one milligram in half a liter is fatal. Lower concentrations frequently cause nausea and vomiting. The compound is a lacrimator (tear gas) at concentrations as low as one milligram in one hundred and ten liters. Chlorpicrin was used in the last war by both the Germans and the Allies.

Diphosgene (Slide 6) is a lung injuriant of low persistence. Authorities differ as to the lethal concentration for a ten minute exposure. The estimates vary from one milligram in two to one milligram in twenty liters of air. The lower limit of irritation is about one milligram in two hundred liters. Diphosgene was used in the last war by both the Germans and the Allies.

Phosgene (Slide 7) is, of all the war gases listed, the one most likely to produce fatalities. In the A.E.F. in France, about one in twenty of the phosgene casualties died from the effects of the gas. These casualties amounted to nearly one-fourth of the total gas casualties. The reason for the very high fatality rate quoted is that phosgene, of all the common war gases, is the one best adapted for surprise attacks in the field. Because of the great volatility of this compound, high atmospheric concentrations of it can be readily and rapidly produced. These are of short duration, but, while they last, they are capable of causing serious casualties in less time than it takes to put on a gas mask. Ten minutes exposure to a concentration of one milligram of phosgene in twenty liters is fatal. The lower limit of irritation is one milligram in two hundred liters. At extremely low concentrations, phosgene can easily be detected by the simple procedure of lighting a cigarette, for it imparts to tobacco a particularly vile reek. It is possible to live for days in an atmosphere containing enough phosgene to make smoking a misery without undergoing any injury--except to the temper. Phosgene was used by both the Germans and the Allies in the last war.

Chloracetophenone (Slide 8), developed since the close of the last war, is a lacrimator which produces definite irritating effects at concentrations as low as one milligram in thirty-three hundred liters. It is a solid at ordinary temperatures, and, hence, must be heated in order to be distributed in the atmosphere. For use in the field, it is therefore mixed with combustible or explosive materials. Chloracetophenone is the substance used for training personnel in the use of gas masks because, although it is an excellent lacrimator, it almost never produces serious or permanent effects. It is solely a harassing agent. For this reason, it is also used occasionally by the police in quelling riots.

Diphenylchloroarsine (Slide 9), probably the best of the sternutators or sneeze gases, is irritant at concentrations as low as one milligram in two thousand liters. ~~It is a solid at ordinary temperatures as low as one milligram in two thousand liters~~. It is a solid at ordinary temperatures and hence must be heated before it is distributed. This heating is done by mixing the compound with high explosives or combustibles. The hot vapors quickly solidify and form a toxic smoke. It is principally on account of such toxic smokes that filters as well as adsorbents must be used in military gas masks. These smokes, however, are not of long persistence. The difficulty in producing high atmospheric concentrations of diphenylchloroarsine is so great that, in spite of the strong toxicity of this compound, it seldom produces fatalities. Primarily, it is a harassing agent. Diphenylchloroarsine was used by the Germans during the first World War, but never, so far as I know by the Allies.

[illegible] Ten minutes [illegible] a floor is fatal. [illegible] the consonant ir [illegible]

[illegible]

Recently, the War Department has released a certain amount of information about a series of new war gases which closely resemble one another, and are known collectively as the "nitrogen mustards". The formulae of these compounds have not been revealed. Some of them are more volatile (and hence less persistent) than mustard gas; others are less volatile and more persistent. But, as a class, they should be regarded as persistent gases. The nitrogen mustards act primarily as skin vesicants; secondarily, as irritants of the eye and the respiratory tract. They would probably be used to produce casualties. The American gas masks afford good protection against them. They are readily hydrolyzed, but their hydrolysis products are toxic. Since the nitrogen mustards have never been actually used in the field, predictions as to their effectiveness are open to a good deal of question.

With these facts about the common war gases in mind, it is interesting to consider which of these agents a distant enemy would be most likely to use in an air raid on a city in the Middle West, and what method of distribution he might employ. I repeat that gas is practically useless as a means of destroying property. Against personnel, it may be used for four different purposes:

(1) To produce casualties.
(2) To harass the enemy by forcing him to use protective measures.
(3) To drive or keep the enemy out of some important area.
(4) To ruin the enemy's morale.

Let me also repeat that the bomb method of aerial attack is applicable to any one of the gases discussed, whereas the spray method can be used only with persistent agents.

I am inclined to think that there is little likelihood of a non-persistent gas being used against any city of this region in an effort to produce casualties. It is true that urban populations (like those of the Middle West) which are unprotected by gas masks are attractive targets for an attack of this kind. But with the bomb method, to put down over any considerable urban area in this region an amount of non-persistent lethal gas sufficient to cause a satisfactory number of casualties would be extremely expensive. Such an attack would require a huge fleet of planes, a large part of which would never return. I doubt if the enemy would ever attempt an air raid of this kind.

That the enemy would undertake to harass the population of our cities with non-lethal gases, such as lacrimators or sternutators, is also improbable. This method is fairly useful on or near the field of battle, because gases of the types mentioned are effective at such low concentrations that a few well-placed shells may interfere for an hour or two with the use of a supply road or seriously reduce the efficiency of artillery during a short but critical period. But the vocations of a civilian population far from the front are not such that harassing its members for a few hours would be of much military value. To harass them continuously for weeks or months might lower their efficiency as producers of military supplies, but that object can be much more readily attained by destroying their tools and buildings with high explosives.

To render any considerable portion of a city in this region untenable by the use of a persistent gas would also be a very difficult undertaking. This method of interdicting terrain works fairly well at or near the front where there is great difficulty in bringing into the gassed area the materials

necessary for decontamination. But in a city, highly organized and far behind the line of battle, decontamination would be relatively easy. The area gassed would probably be cleaned up so rapidly that the attack would fail of its purpose.

There remain, therefore, only two forms of gas attack which, in my opinion, are at all likely to occur in the Middle West. The first of these is an attack made with a persistent gas for the purpose of producing casualties. The second is an attack made with gas of any kind for the purpose of destroying morale--or in plain words, of starting a panic.

In an attack of the first type, the gases to be looked for are Lewisite, the nitrogen, mustards, and ordinary mustard--most probably the latter. It is quite possible that the spray method might be used, and I have already mentioned the surprise feature which may accompany this form of air raid. If such an attack were to occur, I would expect a large number of casualties but comparatively few fatalities, for Lewisite and mustard gas, although excellent casualty producers, rarely cause permanent injuries; only about one per cent of the casualties produced by mustard in the last war were fatal.

In connection with gas attacks intended primarily to start panics, it is well to say a few words about gas morale in the army (what used to be called "gas discipline"), because the problem in a civilian area is very much like the one in the field. It is easy to inspire the ordinary soldier with such a contempt for gas that he disregards the gas alarm and neglects to apply the precautionary measures in the use of which he has been instructed. Under these circumstances, his chances of becoming a gas casualty are enormously increased. On the other hand, it is easy to give to the ordinary soldier such a horror of gas that, at the gas alarm, he quits his post, throws away his weapons and runs for his life. Whether such behavior increases or decreases his chance of survival may perhaps be questioned, but it certainly destroys all his military usefulness. The difficult thing to do is to strike the happy medium between the two extremes just mentioned--that is, to impress the soldier with the idea that gas is a serious matter, but at the same time to inspire him with sufficient confidence in the protective measures at his disposal to keep him at his post and ready for duty. A military unit in which this happy medium has been reached is said to have excellent gas discipline.

The problem of gas discipline in a civilian population does not differ greatly from the military problem just outlined. During an air raid, every air raid precautions worker is as much on duty and as firmly anchored to his job as a sentry in a front line trench. At such times, the ordinary citizen has, it is true, no post of duty. But if he loses his head and dashes wildly about, he not only exposes himself to needless risk, but seriously interferes with the workers who have duties to perform. The civilian situation in the Middle West is in one respect even more difficult than the military one, since there is reason to anticipate that, for a long time at least, the ordinary citizen in this region will have no gas mask.

The all important role played by the medical profession in the matter of civilian gas discipline should be ~~almost~~ self-evident. During a gas attack, the layman will look to the medical man not only for the usual service and advice but also for leadership. If the doctor, who is supposed to understand the gas situation, goes calmly about his business, the ordinary citizen, encouraged by this example, will probably pick up his spirits and meet the situation bravely. On the other hand, any sign of flinching on the part of the medical men will undoubtedly demoralize a large part of the populace.

As for the sort of gas which might be expected in a gas attack intended to produce panic, there is little to be said. Any one of the compounds listed might possibly be used. In fact, if the gas discipline of the population were bad enough, the use of a toxic substance would be superfluous. Any irritant and malodorous material would produce the desired result. A certain percentage of nervous persons is to be found in every population, and any air raid, by opening sewers, demolishing storage tanks or breaking bottles, is almost bound to release bad odors. Hence, it is to be expected that, whether or not gas is used by the enemy, there will be plenty of persons who, during any attack from the air, will be fully convinced that they are being gassed. Briefly, in air attacks on civilian areas, it may be expected that the use of gas will be rare, but that gas alarms will be frequent.

Turning to the matter of defense against gas, it appears that an anti-gas defense program for a civilian area is divisible into two parts in the manner customarily employed in the military text books. Undoubtedly, the best anti-gas ~~aircraft~~ defense for such an area is a balloon barrage, a plentiful supply of anti-aircraft artillery and a large fleet of interceptor planes. These constitute the chief means of what is called "active defense" against aerial attack. To what extent the cities of the Middle West have been provided with such means of active defense I know no more than you. But I am inclined to guess that, for excellent military reasons, not much along this line has been attempted. In any case, the whole subject of active defense lies outside the scope of the present lecture, for this sort of defense is exclusively the function of the armed forces.

In the passive defense of a city against gas, on the other hand, the civilian population plays the chief role. Under the head of passive defense come such items as gas identification, gas-proof shelters, protective clothing, gas masks, decontamination, and all forms of therapy, including first aid. Such defense measures may be classified in two ways. In the first place, they are either communal or individual. Gas proof shelters are communal; gas masks are individual. In the second place, they are either preventative or curative. Gas-proof shelters, protective ointments, protective clothing and gas masks are preventative; first aid and further forms of therapy are curative; what has hitherto been called decontamination partakes of both characters.

In regard to the communal aspects of anti-gas defense, I shall have very little to say. In your capacity as medical men, you will not be called upon to gas-proof buildings or to wash walls and pavements with hypochlorite solution. It is certainly desirable that, in every medical establishment, there should be attendants who are familiar with such measures. But they need not be doctors. If any of you are interested in these aspects of anti-gas defense you will find them adequately discussed in Col. A. M. Prentiss's book entitled "Civil Air Defense". The O.C.D. pamphlet on "Protection against Gas" is also a valuable guide.

One aspect of communal defense against gas does, however, require brief discussion at this point. Obviously, the treatment of any war-gassed patient should be preceded by a determination of the particular toxic agent which is the cause of his injury. Gas identification partakes of the nature of diagnosis, and is thus closely tied in with the work of the doctor.

Gas identification is a subject which came under active discussion as soon as gas began to be used as a military weapon. During the last war, however, nothing very striking in this line was accomplished. Considerable progress in this field has, however, since been made, and "Gas Reconnaissance Agents" are now being trained in the Gas Specialists Courses given at the War Department's Civilian Protection Schools. The general scheme is to provide such agents with protective clothing and portable testing kits and to give them the training (mostly chemical in nature) necessary to enable them to use this equipment effectively. In most instances, these gas reconnaissance agents will not be medical men. Gas identification in the formal sense of that term, will thus be no part of the doctor's duties. The rough and ready methods of gas identification consist largely of testing by sense of smell. I have already referred to such tests in connection with my description of the various individual gases. Naturally a physician, during a gas attack, would find it particularly valuable to have a nose well trained for such purposes.

Among the individual measures of defense against gas, I shall take up first the matter of ordinary clothing, a subject obviously of importance only when the gas used is a skin vesicant, since such clothing offers no protection whatever against gases acting through the eyes or the respiratory tract. The only important skin vesicants are mustard gas and the arsenicals, all of which, and particularly mustard, are persistent. Clothing offers little or no protection against the action of these compounds in the vapor state, but this action is relatively mild. All of the gases in question are, however, high-boiling liquids which can be distributed as fine droplets. These adhere to any surface on which they may fall, and evaporate slowly. Brushing against such contaminated surfaces is what causes the severer forms of mustard gas and arsenical burns. In such situations clothing becomes important; but its role is highly equivocal. At the moment of attack, it protects by shielding the body from contact with gas-contaminated objects. In a spray attack, it would also protect against the slowly-falling droplets. If a person thus exposed can retire quickly from the gassed area, and, once he is outside, can immediately discard his clothing, he will find that his garments have afforded him considerable protection. They have, however, merely absorbed but not destroyed the gas. Both mustard and the arsenicals penetrate not only woollen and cotton fabrics but even leather and rubber. A person wearing clothing contaminated with these persistent gases may, when he evacuates the gassed area, carry with him enough of the toxic agent not only to injure himself severely but even to make him a source of grave danger to others who have not been directly exposed. There are plenty of instances on record where soldiers have had their clothing contaminated with mustard gas without knowing that such was the fact. Not suspecting the danger, they entered dugouts while still wearing the contaminated garments. The result was that not only they themselves but all the occupants of the dugouts became casualties. Contaminated clothing, if not quickly discarded, not only is no protection but is actually a menace.

Many efforts have been made to develop gas-resistant or gas-proof clothing. It should be possible to do this either by impregnating ordinary garments with chemicals which neutralize the toxic substance, or by preparing suits made of fabrics which are relatively impervious to the toxic compounds in question. Attempts along both of these lines have met with some success, but the measures as yet devised are of very limited application. It is possible to impregnate the clothing of soldiers in the field with neutralizing substances. But the impregnating materials have a tendency to injure the cloth. Moreover, they soon loose their efficacy, and reimpregnation becomes necessary. A complete costume made of gas-resistent fabric is almost as cumbersome as a diver's suit; and if the gas concentration is high, the costume is good for only a few hours' wear.

Then it begins to leak and must be removed and decontaminated. Such suits may be used effectively by small groups of specially trained personnel--decontamination squads for instance. But the fatigue which they cause is so extreme that two hours is about the limit of the time during which they can be continuously worn. Moreover, the wearer of such a suit can do only rough heavy work. A doctor clad in such garments would be unable to give to patients anything more than the simplest sort of first aid. The small minority of physicians attached to mobile units or cleansing stations may eventually be given some sort of gas resistant clothing. But if the system planned for the handling of air raid casualties works out as intended, the doctors caring for casualties of this kind in hospitals will need no such protection.

Another anti-vesicant protective measure upon which a good deal of effort has been expended is the preparation of prophylactic ointments or washes. The idea is to spread these upon the skin before the gas attack begins. The chemicals contained in such medicaments are supposed to neutralize the vesicant agents and thus to prevent them from causing casualties. I am unfortunately unable to tell you whether measures of this kind have met with any considerable success. Prophylaxis of the sort here indicated comes very close to first aid. If the subject is of any importance, it will, no doubt, be taken up by the doctors who will give the latter lectures in this course. All that a layman can do is to call attention to the essential opposition between prophylaxis and surprise. Only when sufficient warning of the impending gas attack is received, can prophylactic measures be applied.

A far more important item in the program of individual protection against gas is the gas mask. The development of this protective device began immediately after the first German cholorine attack at Ypres in April, 1915. And since the prejudice against gas warfare has never extended to anti-gas defense, this development has been continuous from that time onwards. The result is that the military gas mask has reached a high degree of perfection. Today it offers good protection against all the well-known war gases, insofar as these act on the face, or eyes, or through the respiratory tract. Naturally, it offers no protection whatever against gases acting on other portions of the body.

All gas masks now used as protection against war gases work on the same general principle. The mask consists of a shaped rubber piece which covers the face and fits closely over the forehead, down the cheeks, and under the chin. This face piece is provided with transparent eye pieces and a head harness to hold the mask in place. The inspired air is drawn in through a tube which fits tightly into a hole in the face piece. This air, on its way in, passes through a canister containing filters and adsorbents which remove any toxic gases or smokes that may be present. The expired air passes out through a rubber flutter valve attached to the lower part of the face piece. This valve permits no air to enter.

An efficient mask constructed on the principle just described offers excellent protection against the common war gases whenever these gases are present in the low concentrations usually met with in the open air. But no adsorbent canister yet devised will protect a man who enters an enclosed space in which a considerable part of the atmosphere has been replaced by poisonous material. Such a person must carry with him a tank containing a supply of compressed fresh air. To this tank his gas mask is connected. Equipments of this latter type are used in civil life by fireman, mine rescue squads and others whose work requires them occasionally to enter badly polluted atmospheres. Such masks are, however, both

expensive and cumbersome. Moreover, the ability to use them efficiently can be acquired only through long training; for this reason, they can be issued only to small groups of carefully selected personnel. Although equipments of the mine-rescue type offer ample respiratory protection against the war gases, it is out of the question to issue them either to the soldiers at large or to any considerable part of the civilian population.

The principle adsorbent used in the canister of the military gas mask is charcoal. But the ability of a given amount of charcoal to adsorb any particular gas is limited. Consequently, if the mask is worn long enough, the charcoal becomes, so to speak, saturated, and the canister begins to leak--that is, to permit the passage of small quantities of the toxic agent. This leakage is slow at first, but becomes more rapid as time goes on and the adsorbtive efficiency of the charcoal decreases. The higher the concentration of the toxic gas, the sooner will the leakage commence and the more rapidly will it increase. When a canister has thus broken down, it may be removed and replaced by a fresh canister without renewing the entire mask. Such replacement of the canister can, however, be safely made only in an interval between gas attacks.

The military gas mask is a fairly delicate instrument. Rough handling may easily distort or tear it. When not in use, it must be kept in a cool place, for some of its parts, when heated, tend to lose their shape and elasticity. The canister must be kept dry, for it is completely ruined by water. Besides there is a technique for adjusting such a gas mask and testing its fit..Consequently, a certain amount of training in the wear and care of the military mask is essential. For an adult of normal intelligence, this training period need not last more than an hour. But merely to issue masks to completely uninstructed persons is of very little use.

The types of military gas mask in use today represent an enormous improvement over most of those issued during the last war, some of which were real instruments of torture. But even the present masks are far from comfortable, and to wear one for four or five hours is a very considerable strain. It must be anticipated that anyone wearing such a mask will become exhausted far more rapidly than he ordinarily would. Moreover, it is extremely difficult for anyone wearing a military gas mask to read or to do precision work of any kind. Lastly, it should be repeated that military gas masks are designed to protect and do protect against war gases only. The protection which they offer against such gases as carbon monoxide, ammonia, methane or sulphur dioxide (which are among the gases most commonly met with in civil accidents) is practically negligible.

When it comes to the question of the distribution of gas masks among the civil population some difficult problems arise. The ideal solution would, of course, be to issue a mask of the highest possible efficiency to each and every individual. But, for practical reasons, such a program is out of the question. Even in England where a mask (or, as the English say, a respirator) has been provided for every man, woman and child on the island, it has not been possible to issue masks of the most efficient type to the populace at large. Nor is it at all essential to do so. What sort of a mask a civilian really needs depends on what he or she is supposed to do during an air raid. The English recognize three catagories in the population:

(1) Those who have no particular duties to perform during air raids, and

who are therefore encouraged to keep out of gas as much as possible. These constitute the bulk of the population. They get the cheapest and least efficient type of mask.

(2) Those who have duties to perform during air raids, but duties which do not involve the handling of gases. This class includes air raid wardens, auxiliary police, auxiliary firemen, ambulance drivers, stretcher bearers--in general, all sorts of air raid precaution workers, who, during an air raid, occupy posts which they must not desert. Every such person gets a mask of intermediate cost and efficiency.

(3) Those whose duties are directly concerned with gas and who may, therefore, be called upon, in the course of these duties, to enter areas of of high gas concentration and to remain in them for some time. Gas reconnaissance agents and men in decontamination squads are the principle members of this class. They need and receive the most costly and most efficient type of gas masks.

The issue of gas masks to civilians in this country is now under way on a limited scale. No attempt has yet been made to supply the population at large, but masks sufficient to equip most of the air raid precaution workers are now being rapidly turned out. These are being distributed first of all in the coastal areas regarded as most open to attack. But the cities of the Middle West have not been forgotten; indeed, in some of them, the masks are already on hand. Just what proportion of these masks will be given to medical personnel I do not know. Presumably, doctors attached to mobile units and cleansing stations will get them; Other physicians are no more in need of such protection than is the ordinary citizen.

The last topic which I wish to mention is what has been called "decontamination". This is a difficult subject to discuss because in the past the term "decontamination" has been applied to a great number of defense measures which are but vaguely connected with one another. The sluicing of pavements with hypochlorite solution, the steam treatment of gas-contaminated clothing and the cleansing of the skin of a gassed patient have all been called "decontamination". Now the O.C.D. has redefined this term. The present official usage is to apply the name "decontamination" to the removal of gas from non-living objects--streets, walls, vehicles, furniture, clothing, etc. The removal of gas from persons is called "cleansing". If this terminology is adhered to, the doctor, in his medical capacity, will not have to concern himself with decontamination. But every doctor should be acquainted with the measures necessary for cleansing, even though the scheme of organization does not call for his carrying out these measures as part of his regular duties.

Cleansing is necessary only when the gas used is a persistent one. A few minutes exposure to fresh air effectively removes all dangerous amounts of non-persistent gases from both THE skin and the clothing of gassed persons. The skin cleansing measures necessary where persistent gases have been used come properly under the head of first aid, and, as such, will be treated by the doctors who will give the medical lectures in this course. According to the official plans, persons who have been gassed with persistent gases but not otherwise injured are supposed to cleanse themselves. An injured man who is unable to care for himself will be taken to a cleansing station. One such station will be connected with every hospital of considerable size, and, where hospitals are few, there will be other stations distributed throughout

the area. At the cleansing station, the patient's clothing will be removed, his skin will be thoroughly freed from gas, and he will be marked in such a way as to identify the toxic agent with which he has been injured. He should, therefore, reach the hands of the regular physician only after all danger of contamination has passed; and he should carry with him enough information about the cause of injury to permit the doctor to perform his functions. Such is the official plan. But it is well to remember that in the excitement of an air raid, even carefully devised schemes do not always work out just as intended. For this reason, every practicing physician should be capable of extending first aid (including skin cleansing) to gassed persons; and every place to which a gassed person is likely to go for assistance (drug stores, police stations, etc.) should be provided with air tight cans where contaminated clothing can be safely stored until it can be rendered innocuous.

In the present lecture, I have tried to give you some conception of the basic principles of gas warfare--the weapons employed, the tactics involved, and the methods of anti-gas defense, insofar as these latter are non-medical in nature. Frankly speaking, my chief concern has been with the matter of morale. To my mind, the most serious feature of the gas situation in the United States today is the feeling which has been produced in the minds of many of our people by twenty years of misguided effort on the part of both the pacifist and the sensational press. The result of this effort is that a fair proportion of our population regards gas warfare much as the inhabitants of mediaeval Europe used to regard pestilence. I do not know whether Hitler has been behind this propaganda, but no form of demoralization could better have served his purpose. It is of supreme importance that no physician should share the superstitious horror to which I refer. Consequently I have tried to show you that gas is just another military weapon. It is by no means to be taken lightly. But when it is countered by defense measures intelligently planned and courageously carried out, there is no reason why it should inspire more terror than any other form of warfare. If gas is ever used against this region, the answer to the question whether or not it will be met as it should be met, will depend very largely on the behavior of the physicians of the Middle West under gas attack. Personally, I have little doubt what the answer will be.

SLIDES

(1) Vesicants — Persistence

	Persistence
Vesicants	
Mustard	High
Lewisite	High
Ethyldichloroarsine	Moderate
Lung Injuriants	
Chlorpicrin	Moderate
Diphosgene	Low
Phosgene	Low
Lacrimator	
Chloroacetophenone	
Sternutator	
Diphenylchloroarsine	Low

(2) Mustard Gas HS
$ClCH_2CH_2SCH_2CH_2Cl$
B.B.-dichlorodiethyl sulphide
M.P. 14° B.P. 217°
Odor: Garlic,horseradish, mustard
Persistence (summer)
24 Hours in open. 1 week in woods
Persistence (winter)
Several weeks in open or woods
Vesicant used to produce casualties

(3) Lewisite M-1
$ClCH=CHAsCl_2$
B-chlorovinyldichloroarsine
M.P. - 18° B.P. 190°
Odor: Geraniums
Persistence (summer)
24 hours in open. 1 week in woods
Persistence (winter)
1 week
Vesicant used to produce casualties.

(4) Ethyldichloroarsine ED
$CH_3CH_2AsCl_2$
Sometimes known as Dick or Ethyl Dick
M.P. - 30° B.P. 156°
Odor: Stinging, like pepper
Persistence (summer)
1-2 hours in open. 2-6 hours in woods
Persistence (winter)
2-4 hours in open. 12 hours in woods
Vesicant and lung injuriant. Used to produce casualties and for harassing purposes.

SLIDES (Cont'd)

(5) Chlorpicrin PS
Cl_3CNO_2
Trichloronitromethane
M.P. 69° B.P. 112°
Odor: Flypaper or anise
Persistence (summer)
1 hour in open. 4 hours in woods
Persistence (winter)
12 hours in open. 1 week in woods
Lung injuriant and lacrimator
Used to product casualties and for harassing purposes.

(6) Diphosgene DP
$ClCOOCCl_3$
Trichloromethylchloroformate
M.P. --57° B.P. 127°
Odor: Acrid, like ensilage.
Persistence (summer)
15 min. in open. 60 min in woods
Persistence (winter)
30 min. in open. 3 hrs. in woods.
Lung injuriant. Used to produce casualties

(7) Phosgene CG
ClCOCl
Carbonyldichloride
M.P. -118° B.P. 8°
Odor: Musty hay or green corn
Persistence (summer)
10 min. in open 30 min. in woods.
Persistence (winter)
20 min. in open. 2 hrs. in woods.
Lung injuriant used to produce casualties.

(8) Chloroacetophenone CN
$C6H_5COCH_2Cl$
Phenylchloromethyl ketone
M.P. 59° B.P. 247°
Odor: Apple Blossoms
Persistence (summer)
Solid lasts for days
Persistence (winter)
Solid lasts for several weeks
Lacrimator used as a harassing agent.

SLIDES (Cont'd)

(9) Diphenylchloroarsine DA
$(C_6H_5)_2AsCl$
M.P. 45° B.P. 383°
Odor: Shoe Polish
Persistence (summer or winter)
5 min. when scattered by detonation of high explosives.

10 min. when scattered from a burning candle.
Sternutator. Used as a harassing agent.

Slide(A) Chemicals in War, by Col. A. M. Prentiss. McGraw Hill, 1937
Civil Air Defense, by Col. A. M. Prentiss. McGraw Hill, 1941
Gas Warfare, by Col. A. H. Waitt. Duell Slaon & Pearce, 1942.
The War Gases, by M. Sartori. Van Nostrand, 1937
War Gases, by M. B. Jacobs. Interscience Publishers, 1942.
The Detection and Identification of War Cases. Chemical Publishing Company, 1942.

[illegible] 11

[illegible] ([illegible]) **[illegible]** ([illegible])

(3) [illegible] [illegible] of
(Continued)
[illegible] [illegible] 1939
[illegible] Snow [illegible]
[illegible] [illegible] of [illegible]
[illegible] [illegible] by [illegible]
[illegible] explosives.

[illegible] [illegible] [illegible] [illegible] from a [illegible]
[illegible] [illegible].
[illegible] [illegible] [illegible] [illegible] [illegible].

[illegible] (4) [illegible] [illegible], by Col. A. M. Prentiss,
McGraw Hill, 1937.
Civilian Defense, by Col. A. M. Prentiss,
[illegible] 1941.
McGraw Hill, 1941.
[illegible] [illegible], by Col. [illegible] [illegible].
[illegible] [illegible] Press, 1942.
[illegible] [illegible] [illegible] by [illegible] [illegible].
[illegible] [illegible], 1937
[illegible] [illegible] by [illegible] [illegible] [illegible].
[illegible] [illegible] [illegible], 1942.
The [illegible] and [illegible] of War
[illegible] [illegible] Publishing Company,
1942.